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Mini Review

A systematic review of prosthetic restoration in patients with shortened dental arches

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Summary The literature regarding the effect of prosthetic restoration in patients having distal extension edentulous space in posterior area (shortened dental arch: SDA) is reviewed in the following article. Information retrieval followed a systematic approach using PubMed. Articles in English published between 1966 and March 2011 describing the outcome of treatment with various prostheses were evaluated. From the search results of 98 articles, 21 articles met the inclusion criteria. Treatment with removable partial dentures (RPDs) improved masticatory function, patient satisfaction and oral health-related quality of life (OHRQoL). However, no significant difference was found in the outcomes between patients with RPDs and with cantilever fixed partial dentures (CFPDs). Caries developed more frequently after treatment with RPDs than CFPDs. The time to survival for CFPDs was not longer than that for RPDs, while more visits to maintain RPDs were required than for CFPDs. No significant difference was found in masticatory function, OHRQoL, and occlusal stability between patients with RPDs and those without restoration of missing molars. Consequently, treatment with RPDs for SDA seems to be less advantageous than CFPDs or no restoration for missing molars. Further research is required to validate treatment with implant-supported fixed partial dentures for SDA.

Introduction

Replacement of missing teeth and maintenance of 28 teeth has been the traditional treatment goal. Removable partial dentures (RPDs), cantilever fixed partial dentures (CFPDs) and implant-supported fixed partial dentures (IFPDs) can be utilized to restore distal extension edentulous space in posterior area. Treatment with RPDs is the most common of these options, because it is noninvasive and inexpensive. However, patients who have missing posterior teeth frequently stop wearing RPDs [1—3]. Furthermore, treatment with RPDs has a high 'biological cost' with high caries incidence and periodontal breakdown of abutment teeth [4—6]. Thus, fixed restorations using CFPDs or IFPDs are recommended as alternative options for replacement of distal extension edentulous space especially in patients who have high risk for caries occurrence and periodontal disease [7—10].

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CFPD has two or more abutments at one end and is left unsupported at the other end. Treatment with CFPDs has been utilized as an alternative treatment option for reduced dentition in patients who refuse treatment with RPDs [11—13]. Restoration for distal extension edentulous space using CFPDs is usually limited up to the second premolar, thus missing molars remain unrestored (premolar occlusion). Käyser named partial edentulism of distal extension edentulous space in posterior area as shortened dental arch (SDA) (Fig. 1) [14]. He proposed that patients with at least 4 occlusal units (premolar occlusion) have sufficient adaptive capacity to maintain oral function [14], and prosthetic rehabilitation should be considered from a problem-oriented approach [15—18]. The Käyser/Nijmegen group then conducted cross-sectional studies and longitudinal studies, and reported that the oral function, occlusal stability and periodontal support of SDA patients were well maintained, and there was no marked effect of lacking molar support on signs and symptoms of temporomandibular disorders (TMDs) [19]. The SDA concept in which missing molars are not restored is widely accepted among dentists in European countries [20—22].

Although some researchers have reviewed literature with respect to validation of the SDA concept proposed by Käyser [19,23], it has not been reviewed systematically whether prosthetic restorations improve oral function of SDA patients. The aim of this article was to systematically review literature regarding the effect of prosthetic restoration in SDA patients. The specific research questions evaluated are (1) whether treatment with RPDs for distal extension edentulous space improves oral function, patient satisfaction and oral health-related quality of life (OHRQoL) compared to treatment with CFPDs (premolar occlusion) or no restoration and (2) what are the advantages/disadvantages of treatment with RPDs over IFPDs, CFPDs or no restoration for SDA.

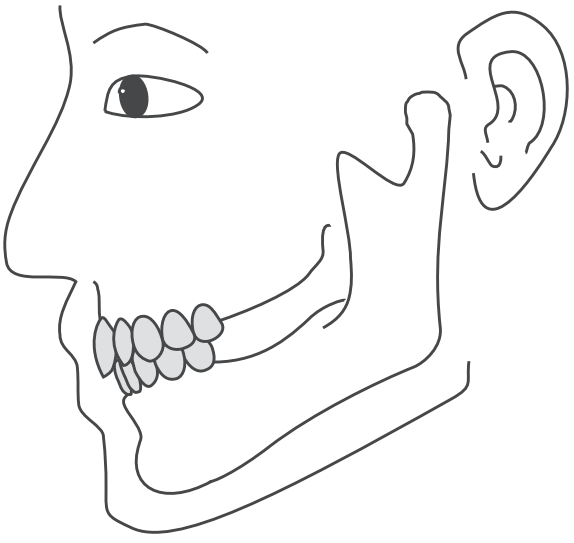

Figure 1 A shortened dental arch in which missing molars are not restored with dentures.

Materials and methods

Search strategy

An electronic database (Medline) was accessed using PubMed to search for all relevant articles published between 1966 and March 2011. Key elements for the search strategy were shortened dental arch or SDA. Articles retrieved were limited to human research published in English dental journals. The articles returned by the databases were then filtered for specific inclusion criteria: (1) articles in which patients had unilateral or bilateral distal extension edentulous space(s) in the posterior region (Kennedy Class I or Class II condition) of maxilla and/or mandible; (2) articles in which the distal extension edentulous space(s) were restored with RPDs, IFPDs or CFPDs; and (3) articles in which statistical comparisons of outcome measures were made within subjects before and after prosthetic treatments, between patients with RPDs, CFPDs, IFPDs or no restoration. Review articles without meta-analysis were excluded. In addition to the database search, relevant articles meeting the inclusion criteria were acquired from references of the retrieved articles by a manual search.

Article analysis

Characteristics of studies such as the authors, publication year, dentition, number of patients, follow-up period, outcome measures and results were extracted from original articles. In this review, treatment with CFPDs that replaced missing posterior teeth up to second premolars (premolar occlusion) and no restoration for missing molars were regarded as the SDA concept, while treatment with RPDs or IFPDs that replace missing posterior teeth to molars were regarded as the traditional concept. Study design was assessed using a clinical epidemiology-based classification. Level of evidence was rated by two authors following the United States Agency for Healthcare Research and Quality (AHRQ, http://www.ahrq.gov/) recommendations (I, meta-analysis of multiple studies; II, experimental studies; III, well-designed, quasi-experimental studies; IV, well-designed, non-experimental studies; and V, case reports and clinical examples).

Results

Ninety articles were identified by PubMed (Last search date; March 17, 2011). Of the 90 articles, 13 articles met the inclusion criteria. In addition, 8 articles which satisfied the inclusion criteria were identified by the manual search (Fig. 2). There were no level I meta-analyses, 10 articles (4 studies) were rated as level II, 2 articles (2 studies) were rated as level III, and 9 articles (6 studies) were rated as level IV, according to AHRQ recommendations (Table 1).

Oral function and nutrient intake

Prospective studies found that the masticatory performance and jaw movement during chewing in patients with mandibular bilateral SDA and maxillary complete denture improved after treatment with mandibular RPDs and new maxillary

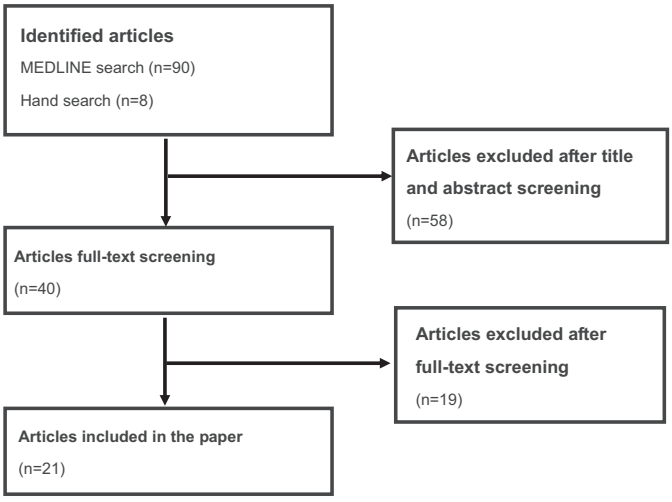

Figure 2 Outline of the literature search.

complete dentures [24,25]. A case-control study reported that the masticatory performance in patients with mandibular bilateral SDA was similar to patients with RPDs, while maximum bite force and tooth contact area in patients with RPDs were significantly greater than that in the SDA patients (no restoration) [26]. Cross-sectional studies found that the perceived chewing ability of patients with RPDs was similar to SDA patients (no restoration) [27—30]. A randomized controlled trial (RCT) found that perceived chewing ability in patients with CFPDs (premolar occlusion) was greater than in patients with RPDs [31]. A prospective study [25] and RCT [32] found that treatment with RPDs did not improve nutrition intake in SDA patients. Cross-sectional studies [27—29], an RCT [33] and a longitudinal study [34] reported that both treatments with RPDs and with CFPDs did not increase clinical signs of TMD, while an RCT found that TMD was more frequently identified in patients with RPDs compared to patients with CFPDs [31,35] (Tables 2 and 3).

Patients satisfaction and QoL

An RCT reported that treatment with RPDs improved patient satisfaction in terms of chewing ability and oral comfort [36]. However, there was no statistically significant difference in the patient satisfaction between patients with RPDs and those with CFPDs [36]. An RCT found that OHRQoL improved after treatment with RPDs, while no statistically significant difference was found between patients with RPDs and those with CFPDs due to small sample size [33]. A cross-sectional study [37] and a case-control study [38] found that OHRQoL and generic QoL in patients with RPDs were of similar level to the SDA patients (no restoration) (Tables 2 and 3). OHRQoL in patients with IFPDs was higher than those with RPDs, while the generic QoL in patients with RPDs was similar to those with IFPDs [38].

Abutment teeth and periodontal tissue

Two RCTs found that caries developed more frequently after treatment with RPDs compared to CFPD treatment [35,39]. Gingival inflammation and plaque accumulation on abutment teeth of RPDs were higher than those of CFPDs 2 and 5 years after treatment, while probing pocket depth, tooth mobility and alveolar bone height were almost identical for both treatments [40,41]. There was no significant difference in tooth mobility, alveolar bone height, occlusal contact, overbite and interdental spaces of remaining teeth between patients with RPDs and SDA patients (no restoration) [30], and identical results were found at a 6-year follow up [42] (Table 3).

Survival time and follow-up treatment

An RCT found that time to survival for RPDs was shorter than for CFPDs, but not statistically significant [43]. A recent RCT found no statistically significant difference in tooth loss after treatment with RPDs or with CFPDs 3 years after treatment [44]. Two RCTs reported that treatment with RPDs required more maintenance visits after treatments compared to CFPDs [31,35,43] (Table 3).

Discussion

Studies comparing treatment outcomes within subjects before and after treatment indicated that RPD improved masticatory function, patient satisfaction and OHRQoL. However, studies that compared the outcomes between subjects found that patients with RPDs did not show significantly greater masticatory performance, patient satisfaction and OHRQoL than for those with CFPDs (premolar occlusion) or no restoration for missing molars. Furthermore, treatment with RPDs showed higher risk for caries incidence, gingival inflammation and poor oral hygiene than treatment with CFPDs. Survival rate and tooth loss in patients with CFPDs were not significantly less than in patients with RPDs, but more visits for maintenance after treatment were required in patients with RPDs. These suggest that treatment with RPDs does not have significant advantage over treatment with CFPDs. Risks for TMD and occlusal instability without restoration of missing molars were not higher than for treatment with RPDs. Therefore, the SDA concept seems to be a more favourable option than treatment with RPDs when considering a mini-

Table 1 Characteristics of articles included in this review.

Authors	Publication year	Evidence level[a]	Study design[b]	Mean age	Dentition of SDA patients	Study group (sample size)[c]	Control (sample size)[d]	Follow-up period	Outcome measures
Budtz-Jørgensen et al.	1987	II	RCT	69	Mandibular SDA and maxillary complete denture	CFPD(27)/RPD(26)	—	2 years	Chewing ability, TMD, caries incidence, maintenance
Isidor et al.	1987	II	RCT	69	Mandibular SDA and maxillary complete denture	CFPD(27)/RPD(25)	—	2 years	Periodontal condition, oral hygiene
Budtz-Jørgensen et al.	1990	II	RCT	69	Mandibular SDA and maxillary complete denture	CFPD(27)/RPD(26)	—	5 years	Clinical outcome
Isidor et al.	1990	II	RCT	69	Mandibular SDA and maxillary complete denture	CFPD(27)/RPD(25)	—	5 years	Periodontal condition
Moynihan et al.	2000	II	RCT	65	Mandibular SDA	Resin-bonded CFPD(30)/RPD(30)		1 year	Nutrition intake
Jepson et al.	2001	II	RCT	67	Mandibular SDA	Resin-bonded CFPD(30)/RPD(30)	—	2 years	Caries incidence
Jepson et al.	2003	II	RCT	67	Mandibular SDA	Resin-bonded CFPD(30)/RPD(30)	—	1 year	Patient satisfaction
Thomason et al.	2007	II	RCT	67	Mandibular SDA	Resin-bonded CFPD(30)/RPD(30)	—	5 years	Survival time, maintenance
Walter et al.	2010	II	RCT	59	Maxillary and/or mandibular SDA	CFPD or NR(106)/ RPD(109)	—	3 years	Survival rate
Wolfart et al.	2005	II	RCT	62	Maxillary and/or mandibular SDA	CFPD(13)/RPD(17)	—	1 year	OHRQoL, TMD
Jemt et al.	1983	III	Pros	61	Mandibular bilateral SDA and maxillary complete denture	RPD(6)	—	5—8 weeks	Masticatory movements
Gunne et al.	1985	III	Pros	61	Mandibular bilateral SDA and maxillary complete denture	RPD(19)	—	2 months	Dietary intake, masticatory performance, chewing ability
Witter et al.	1989	IV	Cross	—	Maxillary and/or mandibular SDA	NR(55)/NR with past experience of RPD(19)/RPD(25)	—	—	Chewing ability, esthetics, occlusal stability, TMD
Witter et al.	1990	IV	Cross	—	Maxillary and/or mandibular SDA	NR(55)/NR with past experience of RPD(19)/RPD(25)	CD(72)	—	Subjective chewing function, esthetics, TMD, functional habit

Witter et al.	1991	IV	Cross	—	Maxillary and/or mandibular SDA	NR(55)/NR with past experience of RPD(19)/RPD(25)	CD(72)	—	Tooth mobility, Alveolar bone height
Witter et al.	1994	IV	Long	—	Maxillary and/or mandibular SDA	NR(55)/RPD(19)	CD(52)	6 years	Occlusal contact, over bite, tooth mobility, alveolar bone height
Witter et al.	1994	IV	Long	—	Maxillary and/or mandibular SDA	NR(55)/RPD(19)	CD(52)	6 years	TMD, chewing ability, esthetics
Leak et al.	1994	IV	Cross	60	Maxillary and/or mandibular SDA	NR(195)/RPD(77)	CD(69)	—	Chewing ability, mandibular function, socio-psychological impact
Kuboki et al.	1997	IV	Cross	59	Mandibular unilateral SDA and maxillary complete dentition	NR(12)/RPD(12)/ IFPD(12)	—	—	Generic QoL, OHRQoL
Armellini et al.	2008	IV	Cross	54	Maxillary and/or mandibular SDA with/ without anterior unrestored missing teeth	NR(65)/RPD(57)	CD(38)	—	Generic QoL, OHRQoL
Aras et al.	2009	IV	Case	56	Maxillary complete dentition and mandibular bilateral SDA	NR(10)/RPD(10)	CD(10)	1 year	Masticatory performance, maximum bite force, occlusal contact area

[a] II: experimental studies, III: well-designed, quasi-experimental studies, IV: well-designed, non-experimental studies.
[b] RCT: randomized controlled trial, Pros: prospective study, Cross: cross-sectional study, Long: longitudinal study, Case: case-control study.
[c] RPD: conventional removable partial denture, CFPD: cantilever fixed partial denture, IFPD: implant-supported fixed partial denture, NR: no-restoration for SDA.
[d] CD: complete dentate subjects.

Table 2 Effect of treatment with RPD on masticatory function, nutrition intake, TMD, patient satisfaction and OHRQoL (comparisons before and after treatment).

Outcomes	Results
Objective masticatory function	
Masticatory performance	Improvement [25]
Jaw movement	Improvement [24]
Nutrient intake	No improvement [25,32]
TMD	No change [33]
Patient satisfaction	
Summary score	Improvement [36]
General satisfaction	–
Appearance	–
Chewing	Improvement [36]
Comfort	Improvement [36]
OHRQoL	Improvement [33]

mum intervention approach. However, it should be noted that the SDA concept may be contraindicated in patients under 50 years of age and with malocclusion such as Angle's Class III or a sever Class II relationship, evidence for parafunction, pre-existing TMD and a marked reduction in alveolar bone support for remaining teeth [45].

On the other hand, evidence for advantage of treatment with IFPDs over RPDs or no restoration is limited [37]. A case control study suggested that treatment with IFPDs has advantage with respect to OHRQoL over treatment with RPDs or no restoration. In the early 1980s, when Käyser proposed the SDA concept, treatment with IFPDs had not been well established in SDA patients. Since then, application of implant-supported dentures has increasingly expanded to treatment for partial edentulism. It is necessary to carry out more clinical studies to validate treatment with IFPDs for SDA as alternatives of RPDs and CFPDs with respect to not only OHRQoL but also patient satisfaction and oral function.

Käyser claimed that treatment with RPDs for SDA is over treatment because of their high biological cost, and thus no restoration for missing molars (SDA concept) is recommended as a limited treatment goal in an aged population with high risk of caries incidence and periodontal disease [7,15–18]. Overall, studies retrieved in this systematic review support his opinion. However, recent studies reported that treatment with RPDs for SDA is a more preferred option than no restoration from the patients' perspective [46,47]. In addition, a recent study showed that SDA patients who complained of chewing inability tended to choose treatment with RPDs [48]. Therefore, treatment with RPDs seems to be a necessary option for SDA from the patients' perspective regardless of the high biological cost, and the SDA concept seems to be applicable in a limited population. Indeed, the SDA concept is widely accepted by dentists in European countries, Tanzania and Japan, but is not widely practised [20,22,49,50]. This discrepancy between the attitude of dentists to the SDA concept and patients' preference for treatment options should be evaluated further.

In Japan, the treatment cost of acrylic resin-based RPD is covered by the national health insurance system, therefore patients can receive treatment with acrylic resin-based RPD at a reduced fee. On the other hand, treatments with metal-

Table 3 Comparison of outcomes between SDA patients with RPD and without restoration, between patients with RPDs and CFPDs or IFPDs.

Outcomes	RPD vs. no restoration (NR)	RPD vs. CFPD
Objective masticatory function		
Masticatory performance	RPD = NR [26]	–
Maximum bite force	RPD > NR [26]	–
Tooth contact area	RPD > NR [26]	–
Perceived chewing ability	RPD = NR [27–30]	RPD < CFPD [31]
Nutrient intake	–	RPD = CFPD [32]
TMD	RPD = NR [27–29,34]	RPD > CFPD [31,35]
Patient satisfaction		
Summary score	–	RPD = CFPD [36]
OHRQoL	RPD = NR [37,38]	RPD = CFPD [33]
Generic QOL	RPD = NR [37,38]	
Caries incidence	–	RPD > CFPD [35,39]
Periodontal condition		
Gingival inflammation	–	RPD > CFPD [40,41]
Probing pocket depth	–	RPD = CFPD [40,41]
Tooth mobility	RPD = NR [30]	RPD = CFPD [40,41]
Alveolar bone height	RPD = NR [30,42]	RPD = CFPD [40,41]
Occlusal contact	PRD = NR [42]	–
Overbite	PRD = NR [42]	–
Interdental space	PRD = NR [42]	–
Oral hygiene	–	RPD < CFPD [40,41]
Time to survival	–	RPD = CFPD [43]
Tooth loss		RPD = CFPD or NR [44]
Maintenance visits	–	RPD > CFPD [30,35,43]

based RPDs, CFPDs and IFPDs are not covered by the national health insurance system. The large difference in costs among treatment options is likely to have a significant influence on decision making. Cost-benefit comparisons among the treatment options for SDA should be investigated in future studies. Socio-economic status of patients, such as gender, income, occupation and educational level, is likely associated with the issue of treatment cost and thus it may confound decision making. Further research is required to investigate how these factors affect the choice of a prosthetic restoration in SDA patients.

Although treatment with RPDs for SDA improved patients' perception of chewing ability, it had no impact on nutrient intake [25,32]. Eating behaviour and food preferences develop over an extended period and they are influenced by a variety of socio-economic, ethnic, and psycho-physiologic factors [51]. Thus, restoration of missing posterior teeth may not be enough to alter dietary habits in terms of nutrient intake.

The majority of studies retrieved in this review were carried out in European countries. Application and limitations of the SDA concept are still being debated in Japan [52,53], because the health care system and socio-economic factors in Japanese SDA patients differ from those in European countries. More evidence based on clinical studies in Japanese SDA patients are required to validate application of the SDA concept in Japan.

Conflict of interest

There are no potential conflicts of interest.

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References

[1] Chandler JA, Brudvik JS. Clinical evaluation of patients eight to nine years after placement of removable partial dentures. J Prosthet Dent 1984;51:736—43.
[2] Cowan RD, Gilbert JA, Elledge DA, McGlynn FD. Patient use of removable partial dentures: two- and four-year telephone interviews. J Prosthet Dent 1991;65:668—70.
[3] Jepson NJ, Thomason JM, Steele JG. The influence of denture design on patient acceptance of partial dentures. Br Dent J 1995;178:296—300.
[4] Zarb GA, MacKay HF. The partially edentulous patient. I. The biologic price of prosthodontic intervention. Aust Dent J 1980;25:63—8.
[5] Wilding RJ, Reddy J. Periodontal disease in partial denture wearers—a biological index. J Oral Rehabil 1987;14:111—24.
[6] MacEntee MI. Biologic sequelae of tooth replacement with removable partial dentures: a case for caution. J Prosthet Dent 1993;70:132—4.
[7] Käyser AF, Witter DJ, Spanauf AJ. Overtreatment with removable partial dentures in shortened dental arches. Aust Dent J 1987;32:178—82.
[8] Jepson NJ, Allen PF. Short and sticky options in the treatment of the partially dentate patient. Br Dent J 1999;187:646—52.
[9] Budtz-Jörgensen E. Restoration of the partially edentulous mouth—a comparison of overdentures, removable partial dentures, fixed partial dentures and implant treatment. J Dent 1996;24:237—44.
[10] Wöstmann B, Budtz-Jørgensen E, Jepson N, Mushimoto E, Palmqvist S, Sofou A, et al. Indications for removable partial dentures: a literature review. Int J Prosthodont 2005;18:139—45.
[11] Budtz-Jørgensen E, Isidor F, Karring T. Cantilevered fixed partial dentures in a geriatric population: preliminary report. J Prosthet Dent 1985;54:467—73.
[12] Himmel R, Pilo R, Assif D, Aviv I. The cantilever fixed partial denture—a literature review. J Prosthet Dent 1992;67:484—7.
[13] Decock V, De Nayer K, De Boever JA, Dent M. 18-Year longitudinal study of cantilevered fixed restorations. Int J Prosthodont 1996;9:331—40.
[14] Käyser AF. Shortened dental arches and oral function. J Oral Rehabil 1981;8:457—62.
[15] Käyser AF, Battistuzzi PG, Snoek PA, Plasmans PJ, Spanauf AJ. The implementation of a problem-oriented treatment plan. Aust Dent J 1988;33:18—22.
[16] Käyser AF. The shortened dental arch: a therapeutic concept in reduced dentitions and certain high-risk groups. Int J Periodontics Restorative Dent 1989;9:427—49.
[17] Käyser AF. How much reduction of the dental arch is functionally acceptable for the ageing patient? Int Dent J 1990;40:183—8.
[18] Käyser AF. Limited treatment goals—shortened dental arches. Periodontology 1994;2000(4):7—14.
[19] Kanno T, Carlsson GE. A review of the shortened dental arch concept focusing on the work by the Käyser/Nijmegen group. J Oral Rehabil 2006;33:850—62.
[20] Allen PF, Witter DJ, Wilson NH, Käyser AF. Shortened dental arch therapy: views of consultants in restorative dentistry in the United Kingdom. J Oral Rehabil 1996;23:481—5.
[21] Witter DJ, Allen PF, Wilson NH, Käyser AF. Dentists' attitudes to the shortened dental arch concept. J Oral Rehabil 1997;24:143—7.
[22] Allen PF, Witter DJ, Wilson NH. A survey of the attitudes of members of the European Prosthodontic Association towards the shortened dental arch concept. Eur J Prosthodont Restor Dent 1998;6:165—9.
[23] Armellini D, von Fraunhofer JA. The shortened dental arch: a review of the literature. J Prosthet Dent 2004;92:531—5.
[24] Jemt T, Hedegård B, Wickberg K. Chewing patterns before and after treatment with complete maxillary and bilateral distal-extension mandibular removable partial dentures. J Prosthet Dent 1983;50:566—9.
[25] Gunne H-SJ. The effect of removable partial dentures on mastication and dietary intake. Acta Odontol Scand 1985;43:269—78.
[26] Aras K, Hasanreisoğlu U, Shinogaya T. Masticatory performance, maximum occlusal force, and occlusal contact area in patients with bilaterally missing molars and distal extension removable partial dentures. Int J Prosthodont 2009;22:204—9.
[27] Leake JL, Hawkins R, Locker D. Social and functional impact of reduced posterior dental units in older adults. J Oral Rehabil 1994;21:1—10.
[28] Witter DJ, van Elteren P, Käyser AF, van Rossum MJ. The effect of removable partial dentures on the oral function in shortened dental arches. J Oral Rehabil 1989;16:27—33.
[29] Witter DJ, Van Elteren P, Käyser AF, Van Rossum GM. Oral comfort in shortened dental arches. J Oral Rehabil 1990;17:137—43.
[30] Witter DJ, De Haan AF, Käyser AF, Van Rossum GM. Shortened dental arches and periodontal support. J Oral Rehabil 1991;18:203—12.
[31] Budtz-Jørgensen E, Isidor F. Cantilever bridges or removable partial dentures in geriatric patients: a two-year study. J Oral Rehabil 1987;14:239—49.

[32] Moynihan PJ, Butler TJ, Thomason JM, Jepson NJ. Nutrient intake in partially dentate patients: the effect of prosthetic rehabilitation. J Dent 2000;28:557—63.
[33] Wolfart S, Heydecke G, Luthardt RG, Marré B, Freesmeyer WB, Stark H, et al. Effects of prosthetic treatment for shortened dental arches on oral health-related quality of life, self-reports of pain and jaw disability: results from the pilot-phase of a randomized multicenter trial. J Oral Rehabil 2005;32:815—22.
[34] Witter DJ, De Haan AFJ, Kayser AF, Van Rossum GMJM. A 6-year follow-up study of oral function in shortened dental arches. Part II. Craniomandibular dysfunction and oral comfort. J Oral Rehabil 1994;21:353—66.
[35] Budtz-Jørgensen E, Isidor F. A 5-year longitudinal study of cantilevered fixed partial dentures compared with removable partial dentures in a geriatric population. J Prosthet Dent 1990;64:42—7.
[36] Jepson N, Allen F, Moynihan P, Kelly P, Thomason M. Patient satisfaction following restoration of shortened mandibular dental arches in a randomized controlled trial. Int J Prosthodont 2003;16:409—14.
[37] Kuboki T, Okamoto S, Suzuki H, Kanyama M, Arakawa H, Sonoyama W, et al. Quality of life assessment of bone-anchored fixed partial denture patients with unilateral mandibular distal-extension edentulism. J Prosthet Dent 1999;82:182—7.
[38] Armellini DB, Heydecke G, Witter DJ, Creugers NH. Effect of removable partial dentures on oral health-related quality of life in subjects with shortened dental arches: a 2-center cross-sectional study. Int J Prosthodont 2008;21:524—30.
[39] Jepson NJ, Moynihan PJ, Kelly PJ, Watson GW, Thomason JM. Caries incidence following restoration of shortened lower dental arches in a randomized controlled trial. Br Dent J 2001;191:140—4.
[40] Isidor F, Budtz-Jørgensen E. Periodontal conditions following treatment with cantilever bridges or removable partial dentures in geriatric patients. A 2-year study. Gerodontics 1987;3:117—21.
[41] Isidor F, Budtz-Jørgensen E. Periodontal conditions following treatment with distally extending cantilever bridges or removable partial dentures in elderly patients. A 5-year study. J Periondontol 1990;61:21—6.
[42] Witter DJ, De Haan AFJ, Kayser AF, Van Rossum GMJM. A 6-year follow-up study of oral function in shortened dental arches. Part I. Occlusal stability. J Oral Rehabil 1994;21:113—25.
[43] Thomason JM, Moynihan PJ, Steen N, Jepson NJ. Time to survival for the restoration of the shortened lower dental arch. J Dent Res 2007;86:646—50.
[44] Walter MH, Weber A, Marré B, Gitt I, Gerss J, Hannak W, et al. The randomized shortened dental arch study: tooth loss. J Dent Res 2010;89:818—22.
[45] Allen PF, Witter DJ, Wilson NH. The role of shortened dental arch concept in the management of reduced dentitions. Br Dent J 1995;179:355—7.
[46] Nassani MZ, Devlin H, McCord JF, Kay EJ. The shortened dental arch—an assessment of patients' dental health state utility values. Int Dent J 2005;55:307—12.
[47] Ikebe K, Hazeyama T, Kagawa R, Matsuda K, Maeda Y. Subjective values of different treatments for missing molars in older Japanese. J Oral Rehabil 2010;37:892—9.
[48] Fueki K, Igarashi Y, Maeda Y, Baba K, Koyano K, Akagawa Y, et al. Factors related to prosthetic restoration in patients with shortened dental arches: a multi-center study. J Oral Rehabil 2010;20. doi: 10.1111/j.1365-2842.2010.02183.x [article first published online].
[49] Sarita PT, Witter DJ, Kreulen CM, Creugers NH. The shortened dental arch concept—attitudes of dentists in Tanzania. Community Dent Oral Epidemiol 2003;31:111—5.
[50] Fujimaki N, Fueki K, Igarashi Y. A questionnaire study of Japanese dentists' perceptions of risks for overeruption of molars without antagonists and attitude on prosthetic intervention. Prosthodont Res Pract 2007;6:246—52.
[51] Gilden JL. Nutrition and older diabetic. Clin Geriatr Med 1999;15:371—90.
[52] Igarashi Y, Ono J, Komiyama Y, Yamashita S. Evaluation to the concept of shortened dental arch; indication and limitation for clinical application. J Jpn Prosthodont Soc 2003;47:41—2.
[53] Igarashi Y, Arai Y, Hattori Y, Fueki K, Yamashita S. Evaluation to the concept of shortened dental arch. 2. Assessment by the multi-sectional scientific research. J Jpn Prosthodont Soc 2003;47:38—40.